FIG. 1 (PRIOR ART)

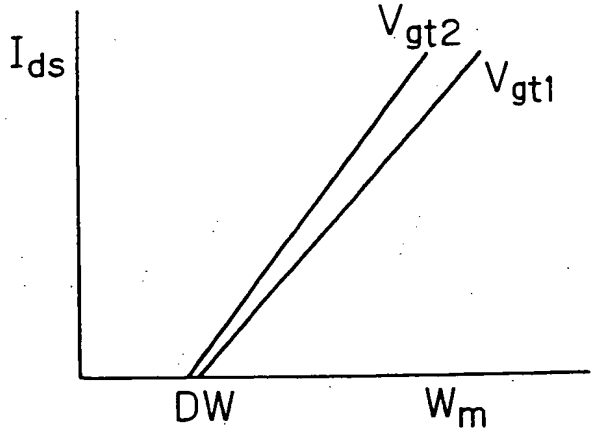


FIG. 2 (PRIOR ART)

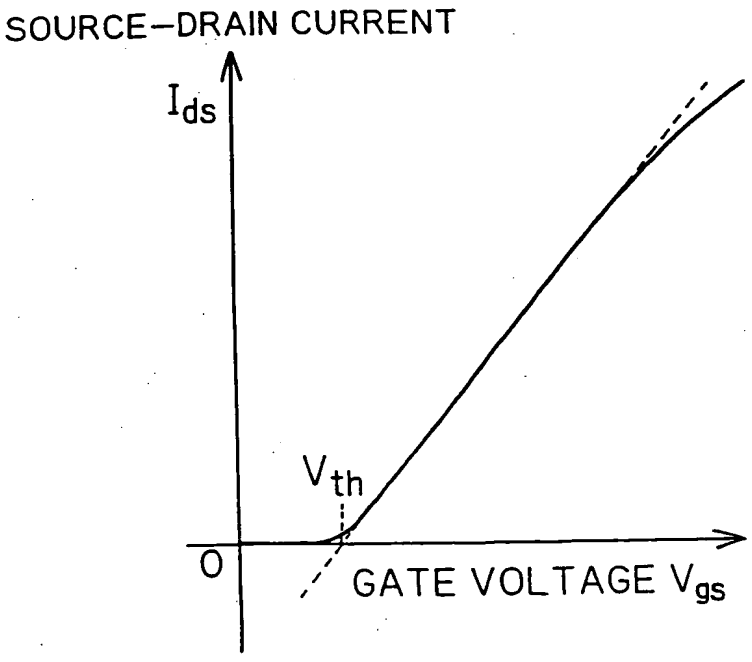


FIG. 3 (PRIOR ART)

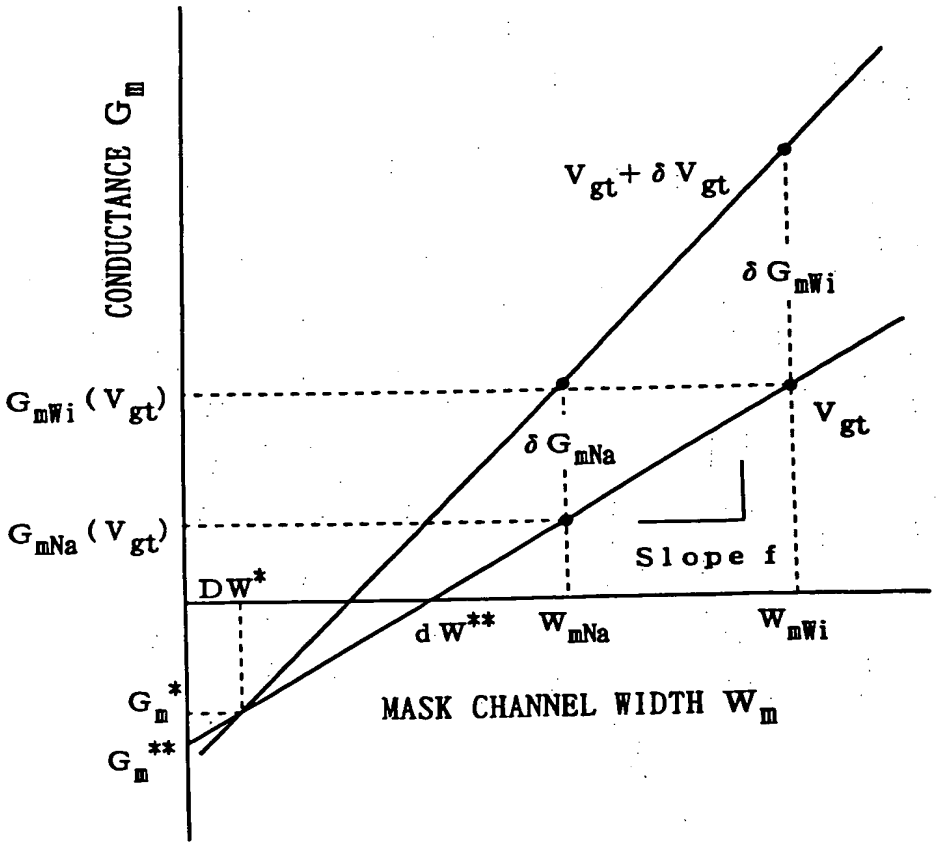


FIG. 4

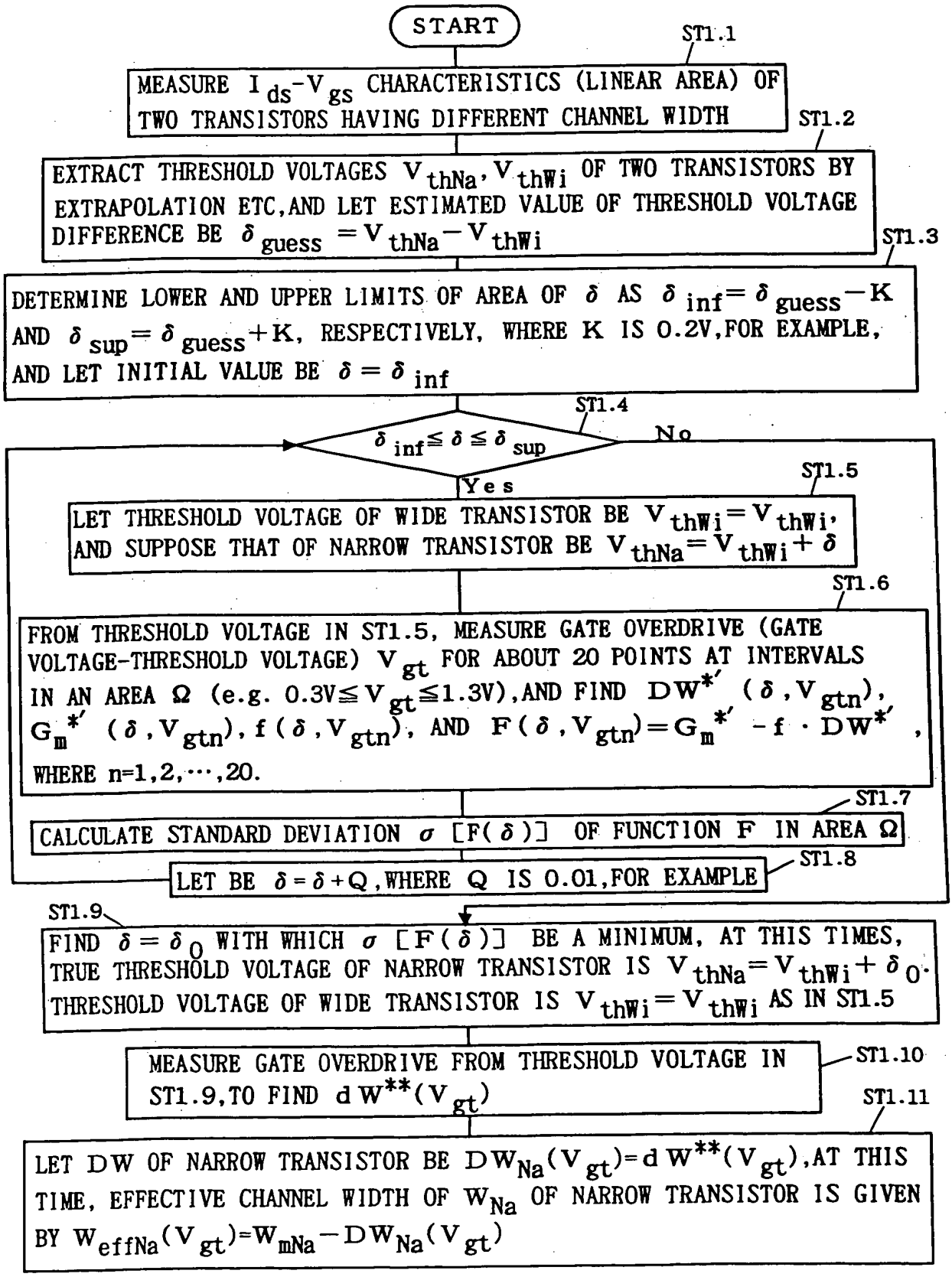

START
ST1.1
MEASURE I_{ds}-V_{gs} CHARACTERISTICS (LINEAR AREA) OF TWO TRANSISTORS HAVING DIFFERENT CHANNEL WIDTH
ST1.2
EXTRACT THRESHOLD VOLTAGES V_{thNa}, V_{thWi} OF TWO TRANSISTORS BY EXTRAPOLATION ETC, AND LET ESTIMATED VALUE OF THRESHOLD VOLTAGE DIFFERENCE BE $\delta_{guess} = V_{thNa} - V_{thWi}$
ST1.3
DETERMINE LOWER AND UPPER LIMITS OF AREA OF δ AS $\delta_{inf} = \delta_{guess} - K$ AND $\delta_{sup} = \delta_{guess} + K$, RESPECTIVELY, WHERE K IS 0.2V, FOR EXAMPLE, AND LET INITIAL VALUE BE $\delta = \delta_{inf}$
ST1.4
$\delta_{inf} \leqq \delta \leqq \delta_{sup}$
No
Yes
ST1.5
LET THRESHOLD VOLTAGE OF WIDE TRANSISTOR BE $V_{thWi} = V_{thWi}$, AND SUPPOSE THAT OF NARROW TRANSISTOR BE $V_{thNa} = V_{thWi} + \delta$
ST1.6
FROM THRESHOLD VOLTAGE IN ST1.5, MEASURE GATE OVERDRIVE (GATE VOLTAGE-THRESHOLD VOLTAGE) V_{gt} FOR ABOUT 20 POINTS AT INTERVALS IN AN AREA Ω (e.g. $0.3V \leqq V_{gt} \leqq 1.3V$), AND FIND $DW^{*'}(\delta, V_{gtn})$, $G_m^{*'}(\delta, V_{gtn})$, $f(\delta, V_{gtn})$, AND $F(\delta, V_{gtn}) = G_m^{*'} - f \cdot DW^{*'}$, WHERE n=1,2,…,20.
ST1.7
CALCULATE STANDARD DEVIATION $\sigma[F(\delta)]$ OF FUNCTION F IN AREA Ω
ST1.8
LET BE $\delta = \delta + Q$, WHERE Q IS 0.01, FOR EXAMPLE
ST1.9
FIND $\delta = \delta_0$ WITH WHICH $\sigma[F(\delta)]$ BE A MINIMUM, AT THIS TIMES, TRUE THRESHOLD VOLTAGE OF NARROW TRANSISTOR IS $V_{thNa} = V_{thWi} + \delta_0$, THRESHOLD VOLTAGE OF WIDE TRANSISTOR IS $V_{thWi} = V_{thWi}$ AS IN ST1.5
MEASURE GATE OVERDRIVE FROM THRESHOLD VOLTAGE IN ST1.9, TO FIND $dW^{**}(V_{gt})$
ST1.10
ST1.11
LET DW OF NARROW TRANSISTOR BE $DW_{Na}(V_{gt}) = dW^{**}(V_{gt})$, AT THIS TIME, EFFECTIVE CHANNEL WIDTH OF W_{Na} OF NARROW TRANSISTOR IS GIVEN BY $W_{effNa}(V_{gt}) = W_{mNa} - DW_{Na}(V_{gt})$

FIG. 5

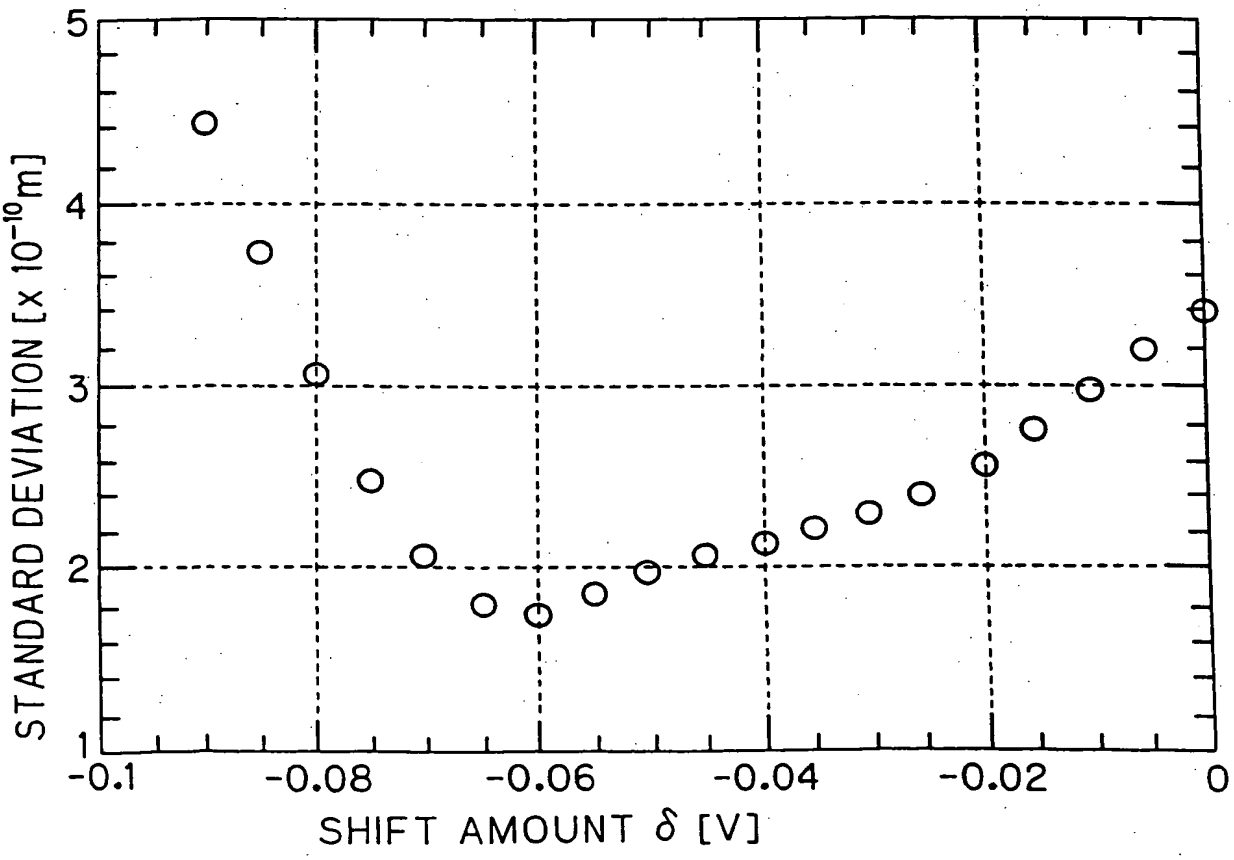

STANDARD DEVIATION [x 10⁻¹⁰m]
5
4
3
2
1
-0.1
-0.08
-0.06
-0.04
-0.02
0
SHIFT AMOUNT δ [V]

FIG. 6

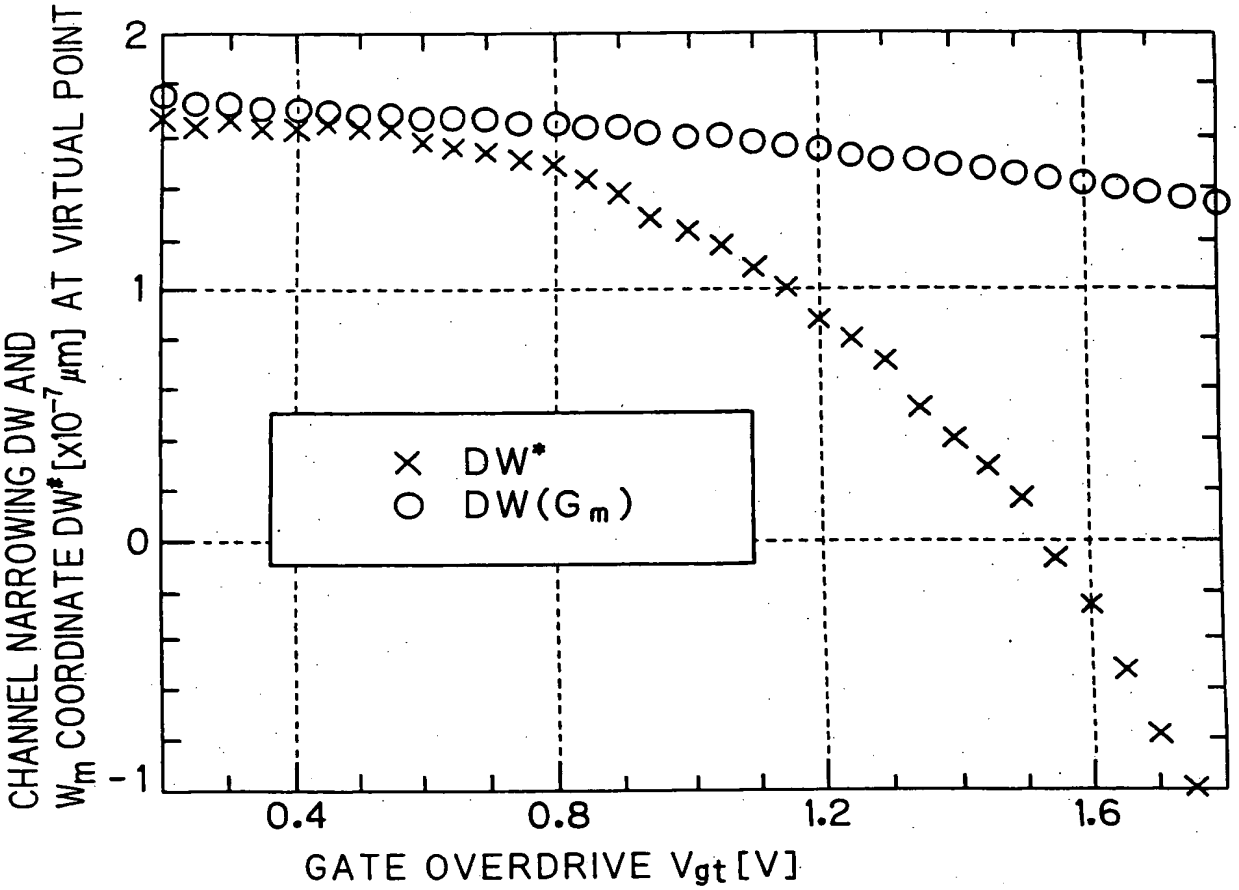

CHANNEL NARROWING DW AND
W_m COORDINATE DW* [$\times 10^{-7}$ μm] AT VIRTUAL POINT
2
1
0
-1
0.4
0.8
1.2
1.6
GATE OVERDRIVE V_{gt} [V]
× DW*
○ DW(G_m)

FIG. 7

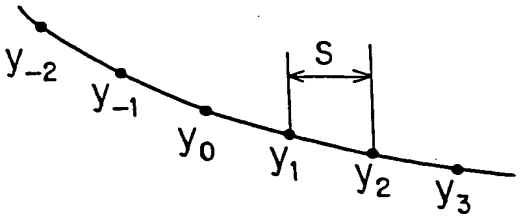

y_{-2}
y_{-1}
y_0
y_1
y_2
y_3
S

FIG. 8

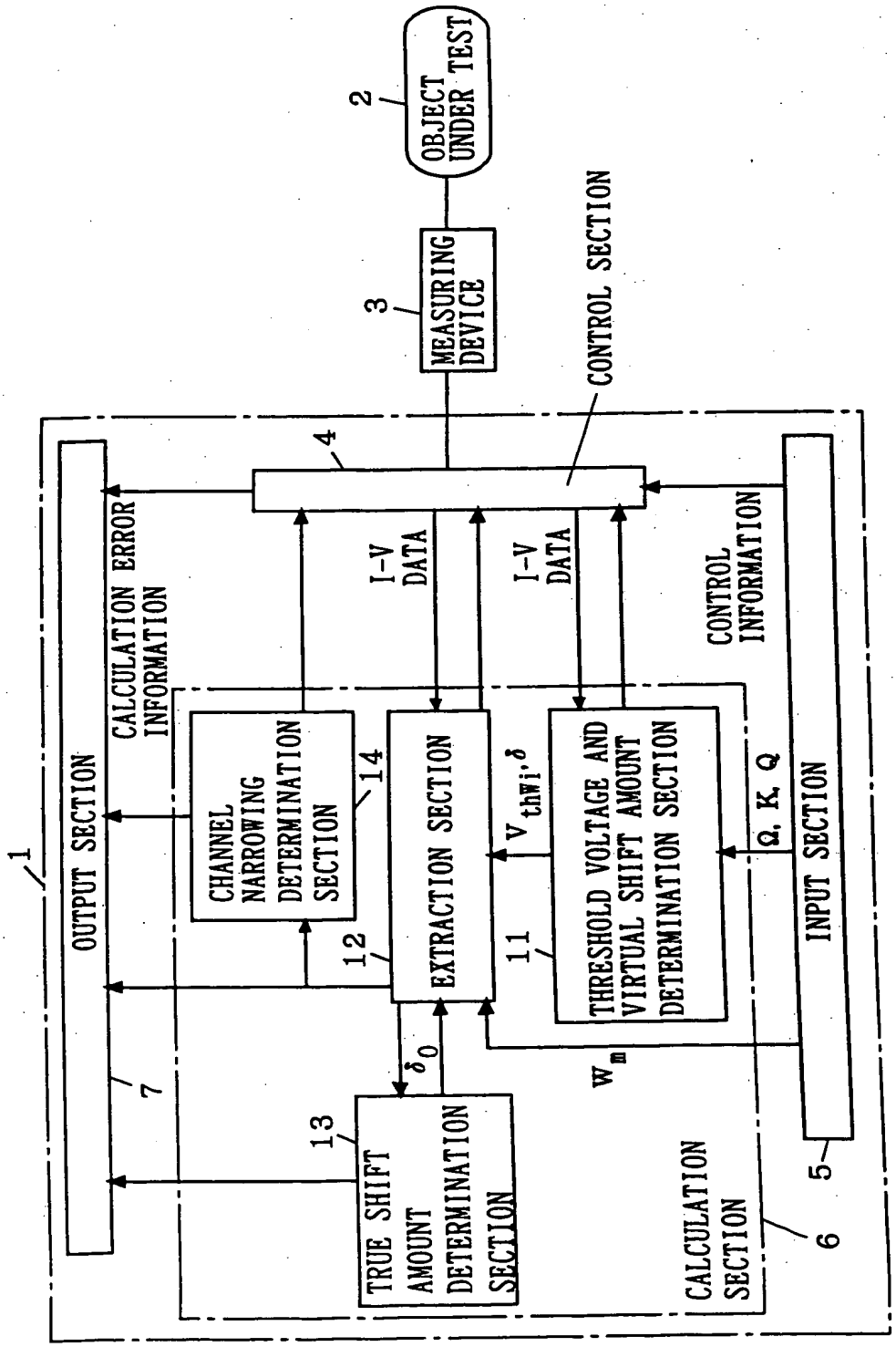

1
2
OBJECT UNDER TEST
3
MEASURING DEVICE
4
CONTROL SECTION
OUTPUT SECTION
CALCULATION ERROR INFORMATION
I-V DATA
I-V DATA
CONTROL INFORMATION
INPUT SECTION
CHANNEL NARROWING DETERMINATION SECTION
14
EXTRACTION SECTION
12
V_{thWi}, δ
THRESHOLD VOLTAGE AND VIRTUAL SHIFT AMOUNT DETERMINATION SECTION
11
Ω, K, Q
δ_0
W_m
7
13
TRUE SHIFT AMOUNT DETERMINATION SECTION
CALCULATION SECTION
6
5

FIG. 9

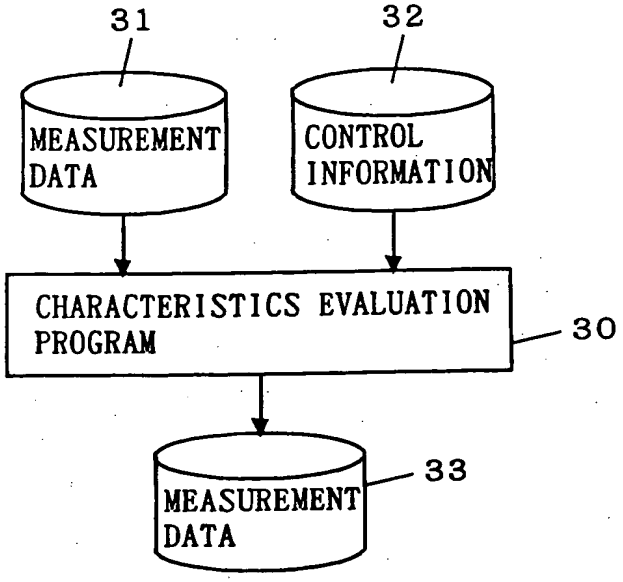

31
32
MEASUREMENT DATA
CONTROL INFORMATION
CHARACTERISTICS EVALUATION PROGRAM
30
33
MEASUREMENT DATA

FIG. 10

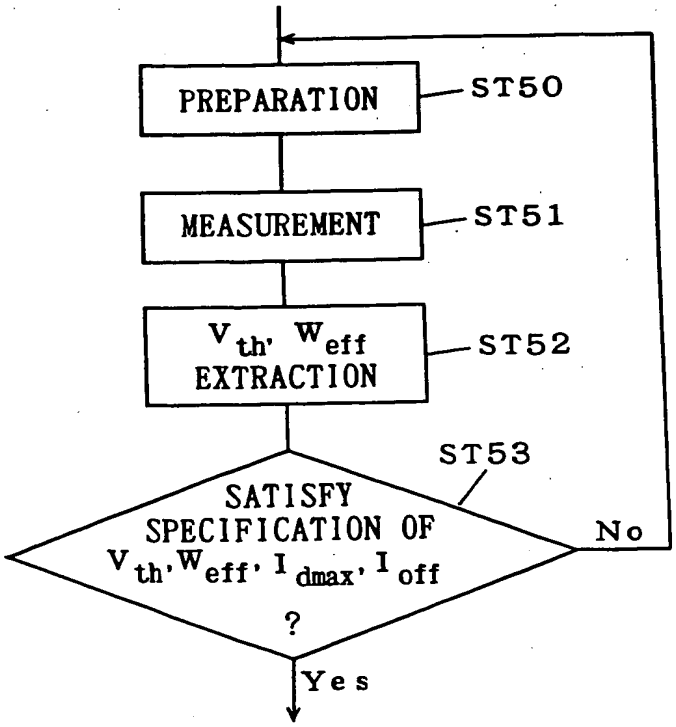

PREPARATION
ST50
MEASUREMENT
ST51
V_{th}, W_{eff} EXTRACTION
ST52
ST53
SATISFY SPECIFICATION OF V_{th}, W_{eff}, I_{dmax}, I_{off} ?
No
Yes

FIG. 11

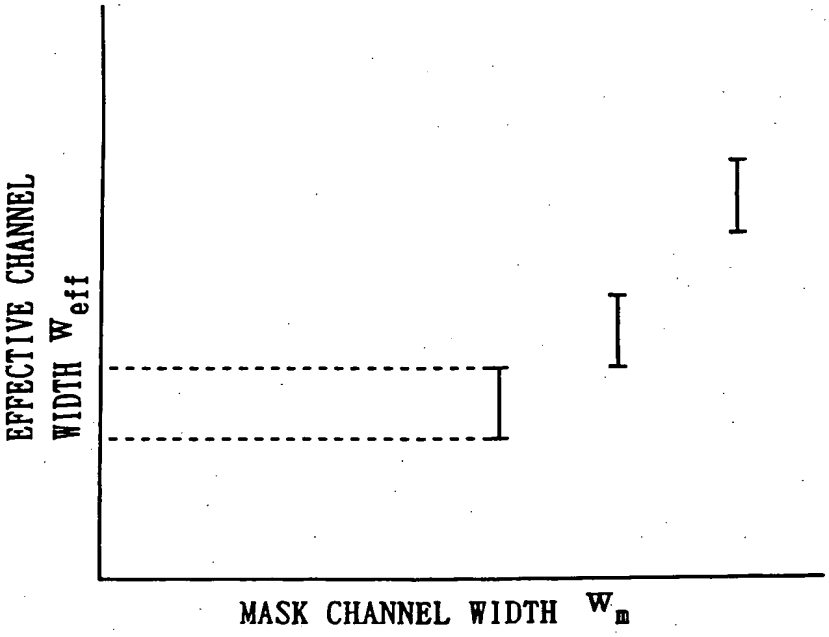

EFFECTIVE CHANNEL WIDTH W_{eff}
MASK CHANNEL WIDTH W_m

FIG. 12

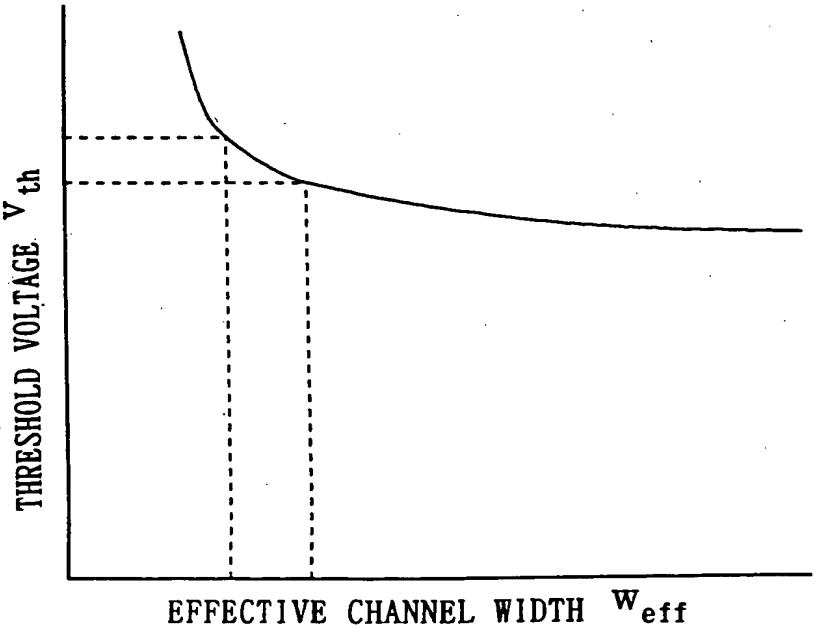

THRESHOLD VOLTAGE V_{th}
EFFECTIVE CHANNEL WIDTH W_{eff}

FIG. 13

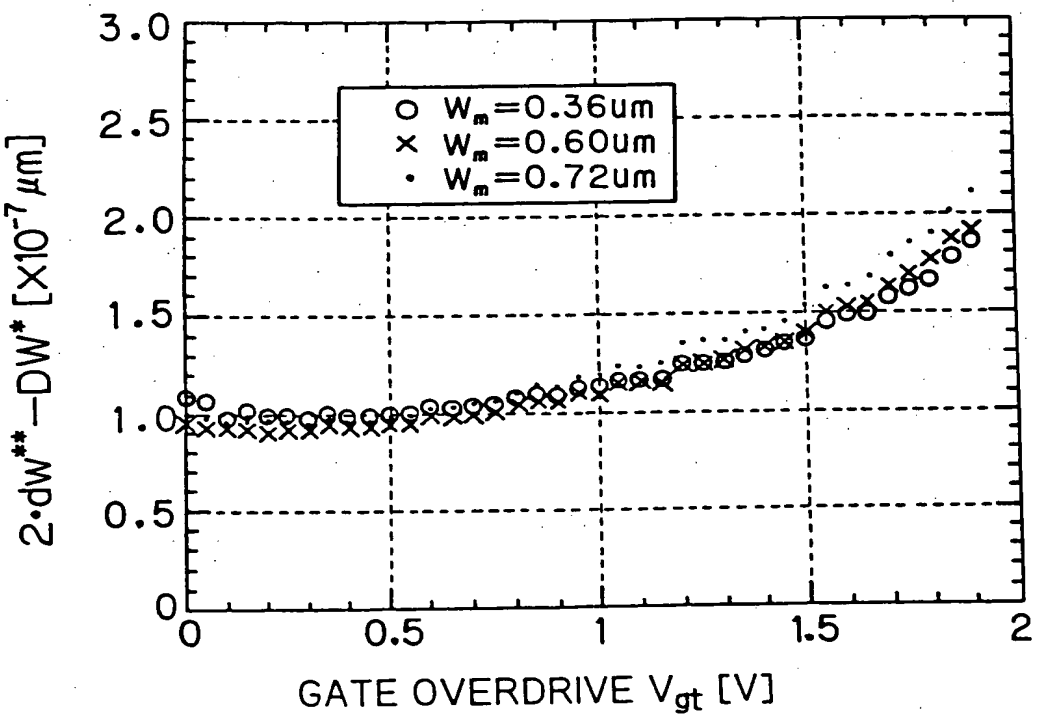

3.0
2.5
2.0
1.5
1.0
0.5
0
0
0.5
1
1.5
2
W_m=0.36um
W_m=0.60um
W_m=0.72um
$2 \cdot dW^{**} - DW^*$ [$\times 10^{-7}$ μm]
GATE OVERDRIVE V_{gt} [V]

FIG. 14

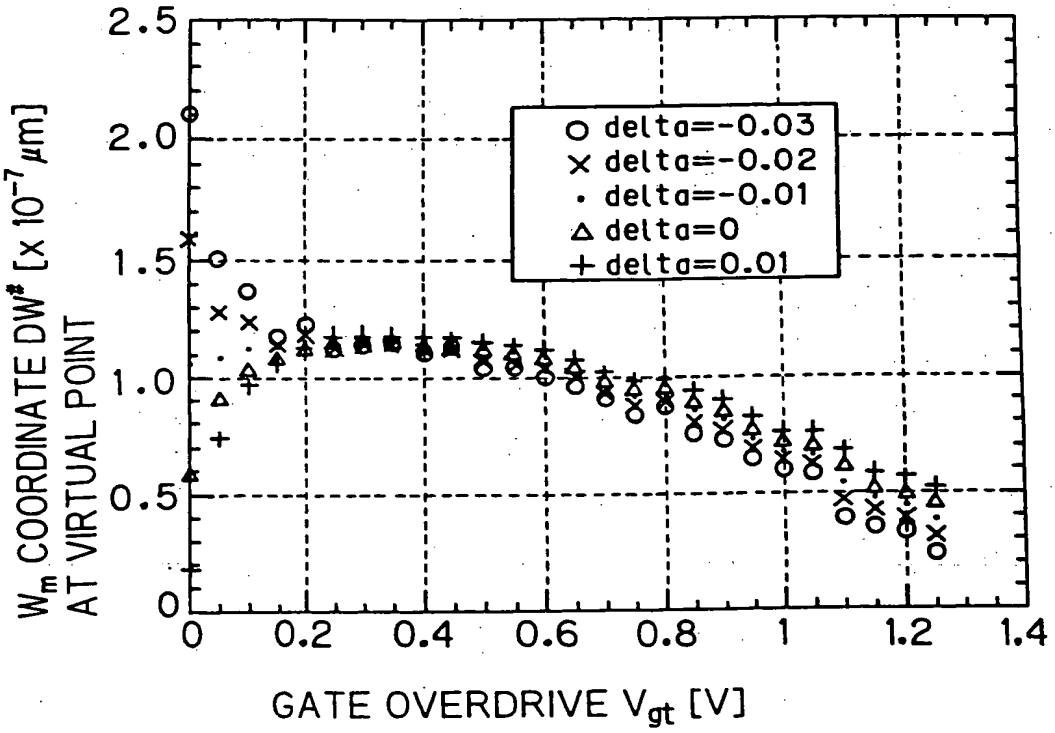

2.5
2.0
1.5
1.0
0.5
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
delta=-0.03
delta=-0.02
delta=-0.01
delta=0
delta=0.01
W_m COORDINATE DW* [x 10^{-7} μm]
AT VIRTUAL POINT
GATE OVERDRIVE V_{gt} [V]

FIG. 15

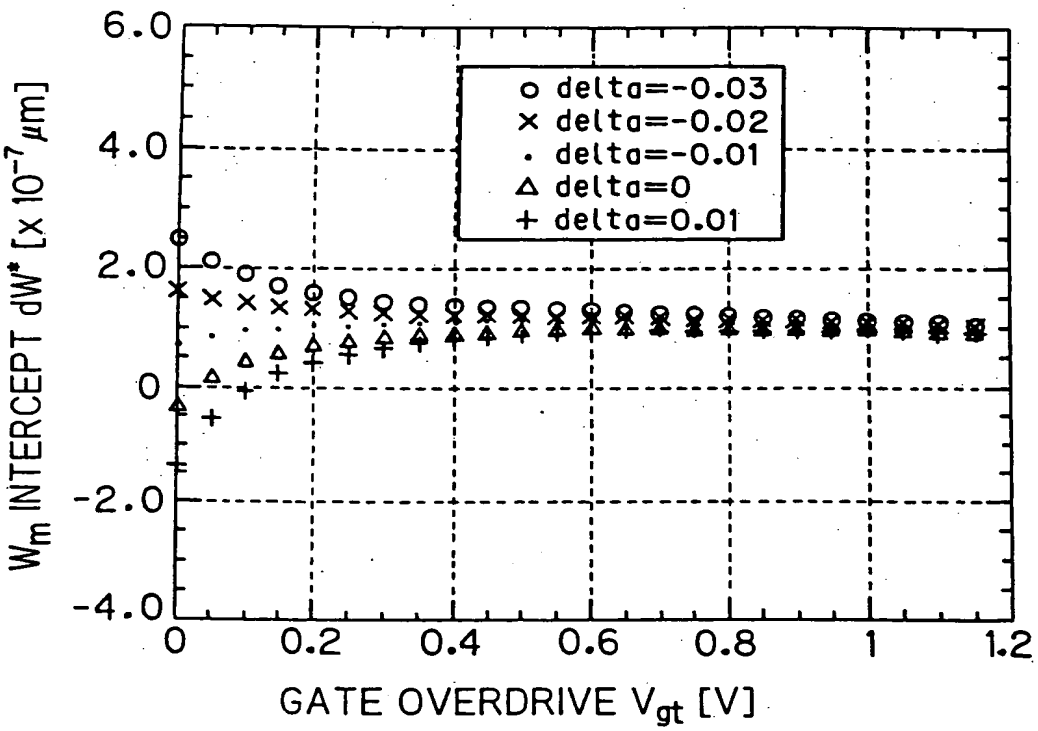

6.0
4.0
2.0
0
-2.0
-4.0
0
0.2
0.4
0.6
0.8
1
1.2
o delta=-0.03
× delta=-0.02
· delta=-0.01
△ delta=0
+ delta=0.01
W_m INTERCEPT dW^* [x 10^{-7} μm]
GATE OVERDRIVE V_{gt} [V]

FIG. 16

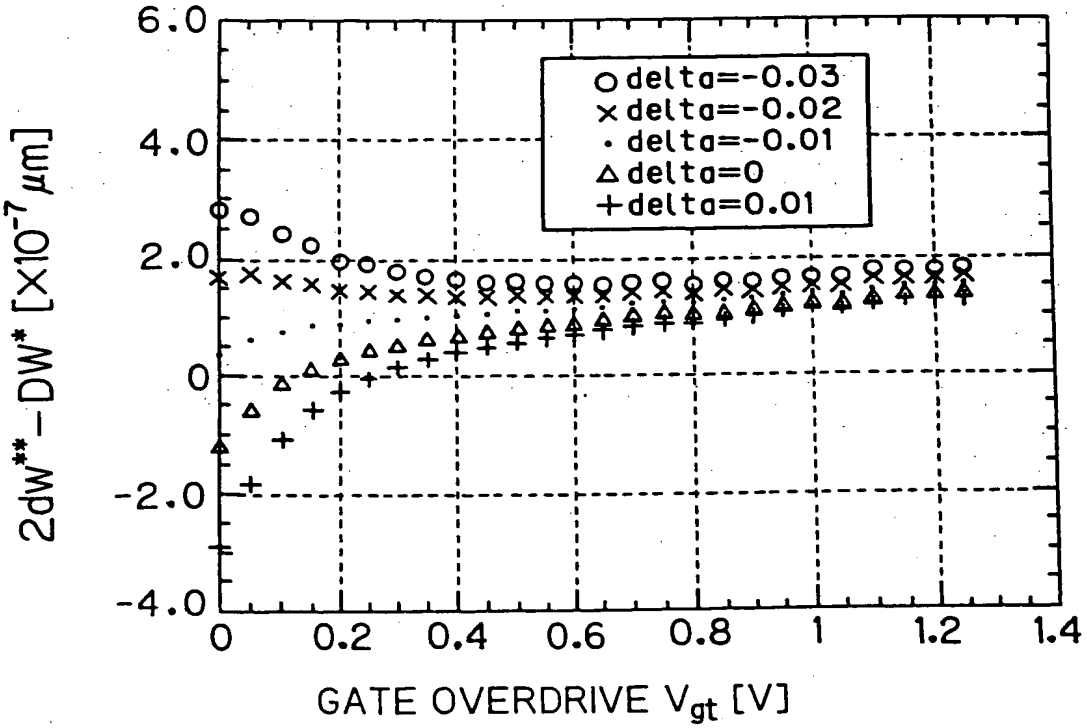

6.0
4.0
2.0
0
-2.0
-4.0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
delta=-0.03
delta=-0.02
delta=-0.01
delta=0
delta=0.01
2dW**-DW* [X10^-7 μm]
GATE OVERDRIVE Vgt [V]

FIG. 17

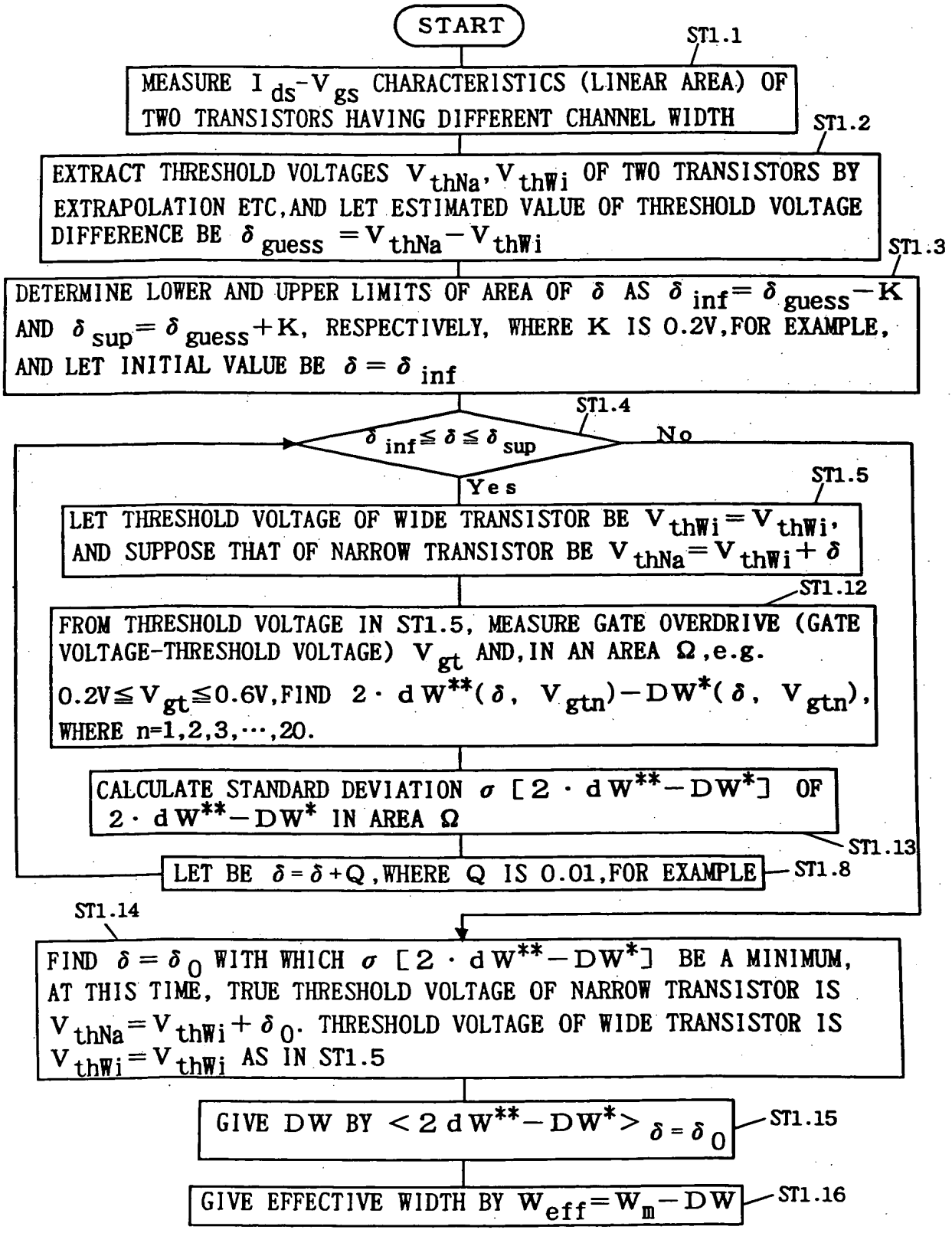

START
ST1.1
MEASURE I_{ds}-V_{gs} CHARACTERISTICS (LINEAR AREA) OF TWO TRANSISTORS HAVING DIFFERENT CHANNEL WIDTH
ST1.2
EXTRACT THRESHOLD VOLTAGES V_{thNa}, V_{thWi} OF TWO TRANSISTORS BY EXTRAPOLATION ETC, AND LET ESTIMATED VALUE OF THRESHOLD VOLTAGE DIFFERENCE BE $\delta_{guess} = V_{thNa} - V_{thWi}$
ST1.3
DETERMINE LOWER AND UPPER LIMITS OF AREA OF δ AS $\delta_{inf} = \delta_{guess} - K$ AND $\delta_{sup} = \delta_{guess} + K$, RESPECTIVELY, WHERE K IS 0.2V, FOR EXAMPLE, AND LET INITIAL VALUE BE $\delta = \delta_{inf}$
ST1.4
$\delta_{inf} \leqq \delta \leqq \delta_{sup}$
No
Yes
ST1.5
LET THRESHOLD VOLTAGE OF WIDE TRANSISTOR BE $V_{thWi} = V_{thWi}$, AND SUPPOSE THAT OF NARROW TRANSISTOR BE $V_{thNa} = V_{thWi} + \delta$
ST1.12
FROM THRESHOLD VOLTAGE IN ST1.5, MEASURE GATE OVERDRIVE (GATE VOLTAGE-THRESHOLD VOLTAGE) V_{gt} AND, IN AN AREA Ω, e.g. $0.2V \leqq V_{gt} \leqq 0.6V$, FIND $2 \cdot dW^{**}(\delta, V_{gtn}) - DW^{*}(\delta, V_{gtn})$, WHERE n=1,2,3,…,20.
CALCULATE STANDARD DEVIATION $\sigma [2 \cdot dW^{**} - DW^{*}]$ OF $2 \cdot dW^{**} - DW^{*}$ IN AREA Ω
ST1.13
LET BE $\delta = \delta + Q$, WHERE Q IS 0.01, FOR EXAMPLE
ST1.8
ST1.14
FIND $\delta = \delta_0$ WITH WHICH $\sigma [2 \cdot dW^{**} - DW^{*}]$ BE A MINIMUM, AT THIS TIME, TRUE THRESHOLD VOLTAGE OF NARROW TRANSISTOR IS $V_{thNa} = V_{thWi} + \delta_0$. THRESHOLD VOLTAGE OF WIDE TRANSISTOR IS $V_{thWi} = V_{thWi}$ AS IN ST1.5
GIVE DW BY $< 2dW^{**} - DW^{*} >_{\delta = \delta_0}$
ST1.15
GIVE EFFECTIVE WIDTH BY $W_{eff} = W_m - DW$
ST1.16

FIG. 18

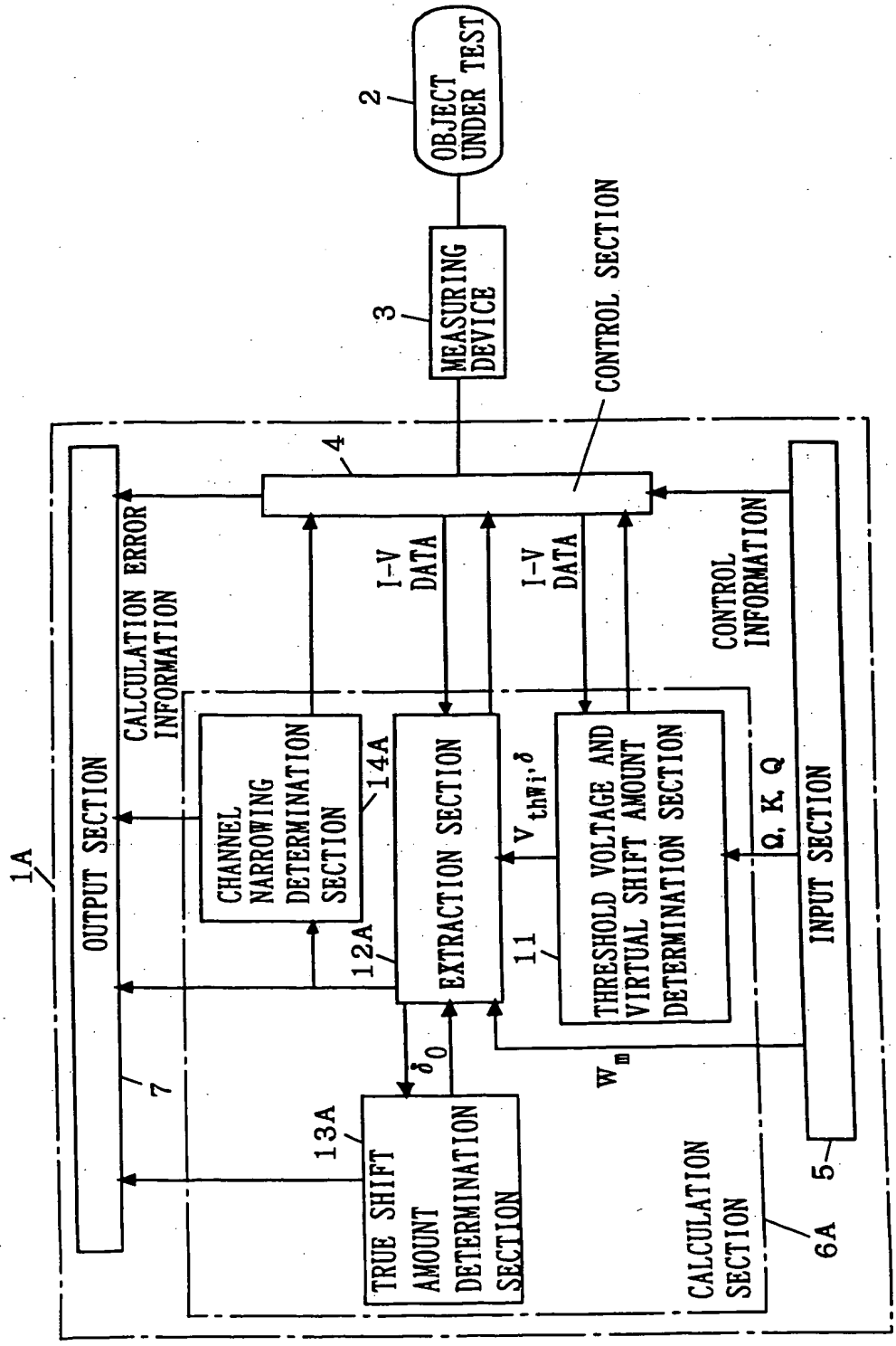

2
OBJECT UNDER TEST
3
MEASURING DEVICE
CONTROL SECTION
4
1A
OUTPUT SECTION
CALCULATION ERROR INFORMATION
I-V DATA
I-V DATA
CONTROL INFORMATION
CHANNEL NARROWING DETERMINATION SECTION
14A
EXTRACTION SECTION
V_{thWi}, δ
THRESHOLD VOLTAGE AND VIRTUAL SHIFT AMOUNT DETERMINATION SECTION
Ω, K, Q
INPUT SECTION
12A
11
7
δ_0
W_m
13A
TRUE SHIFT AMOUNT DETERMINATION SECTION
CALCULATION SECTION
5
6A

FIG. 19

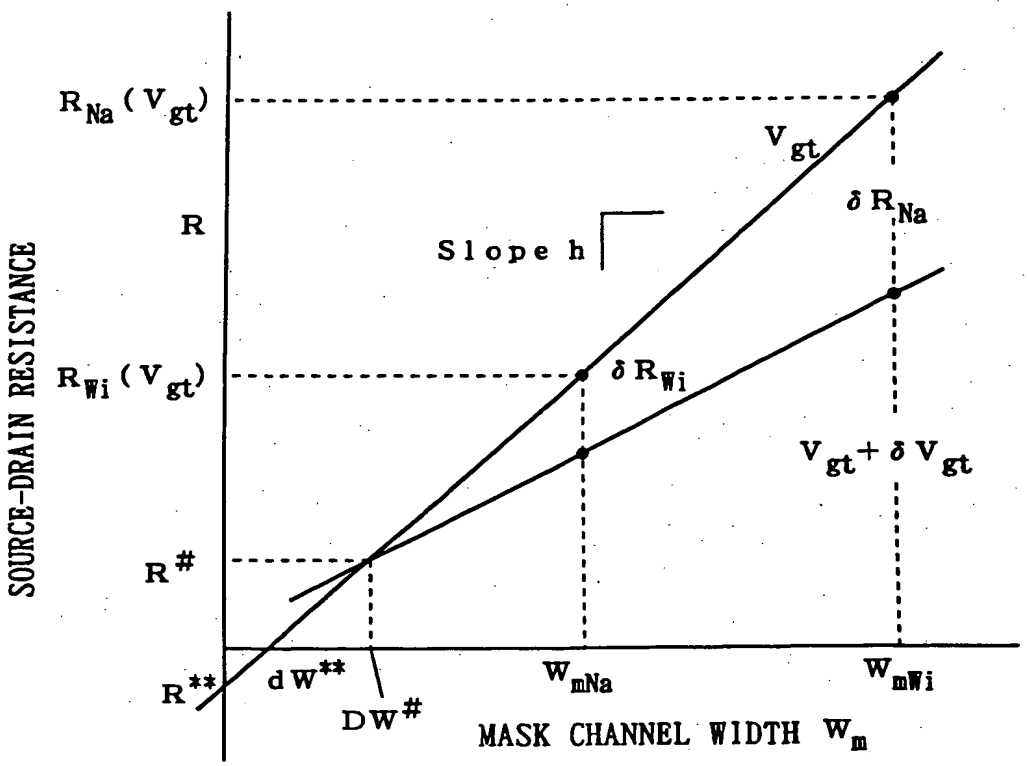

SOURCE-DRAIN RESISTANCE
$R_{Na}(V_{gt})$
R
$R_{Wi}(V_{gt})$
$R^{\#}$
R^{**}
Slope h
V_{gt}
δR_{Na}
δR_{Wi}
$V_{gt}+\delta V_{gt}$
dW^{**}
$DW^{\#}$
W_{mNa}
W_{mWi}
MASK CHANNEL WIDTH W_m

FIG. 20

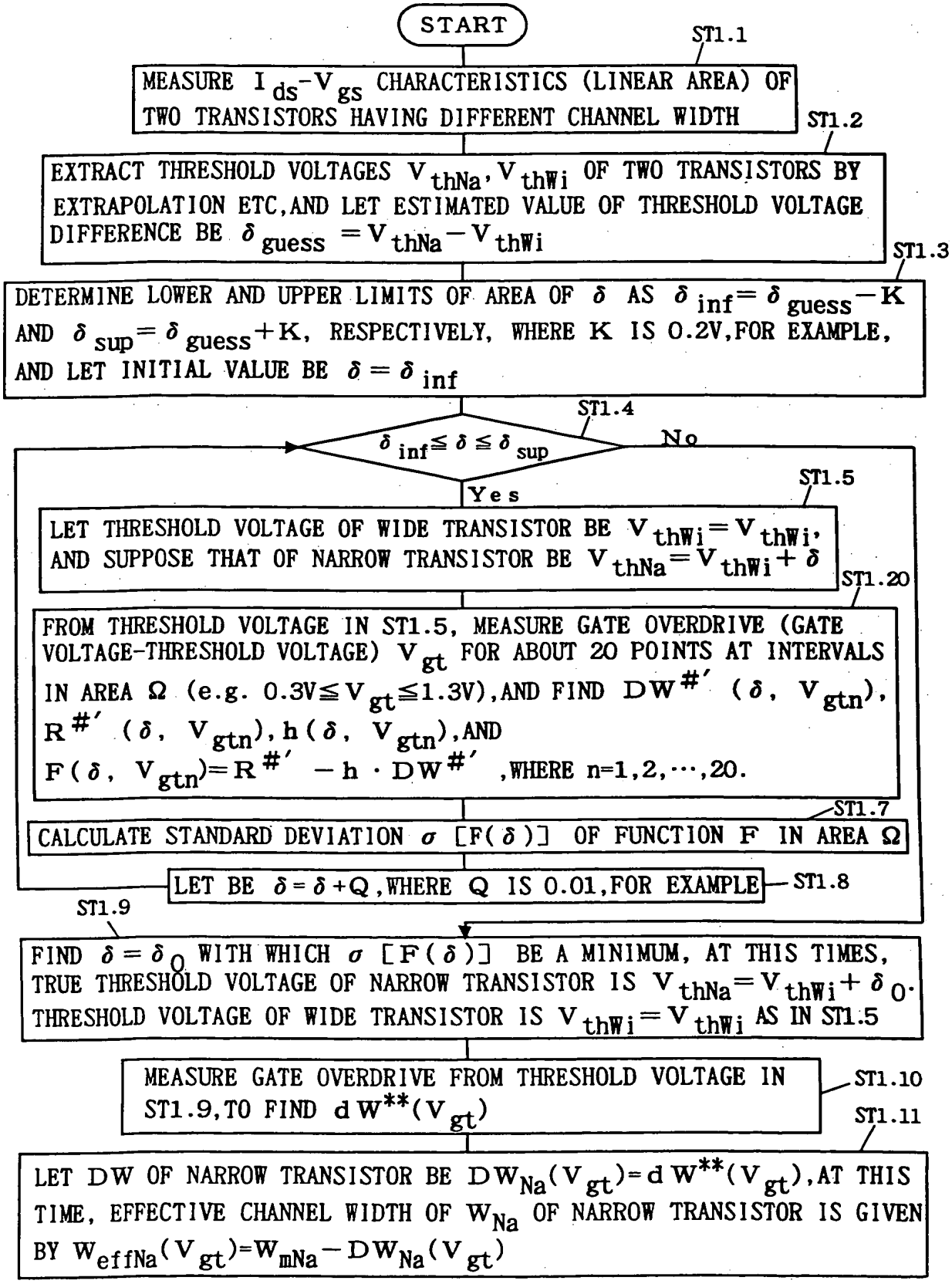

START
ST1.1
MEASURE I_{ds}-V_{gs} CHARACTERISTICS (LINEAR AREA) OF TWO TRANSISTORS HAVING DIFFERENT CHANNEL WIDTH
ST1.2
EXTRACT THRESHOLD VOLTAGES V_{thNa}, V_{thWi} OF TWO TRANSISTORS BY EXTRAPOLATION ETC, AND LET ESTIMATED VALUE OF THRESHOLD VOLTAGE DIFFERENCE BE $\delta_{guess} = V_{thNa} - V_{thWi}$
ST1.3
DETERMINE LOWER AND UPPER LIMITS OF AREA OF δ AS $\delta_{inf} = \delta_{guess} - K$ AND $\delta_{sup} = \delta_{guess} + K$, RESPECTIVELY, WHERE K IS 0.2V, FOR EXAMPLE, AND LET INITIAL VALUE BE $\delta = \delta_{inf}$
ST1.4
$\delta_{inf} \leqq \delta \leqq \delta_{sup}$
No
Yes
ST1.5
LET THRESHOLD VOLTAGE OF WIDE TRANSISTOR BE $V_{thWi} = V_{thWi}$, AND SUPPOSE THAT OF NARROW TRANSISTOR BE $V_{thNa} = V_{thWi} + \delta$
ST1.20
FROM THRESHOLD VOLTAGE IN ST1.5, MEASURE GATE OVERDRIVE (GATE VOLTAGE-THRESHOLD VOLTAGE) V_{gt} FOR ABOUT 20 POINTS AT INTERVALS IN AREA Ω (e.g. $0.3V \leqq V_{gt} \leqq 1.3V$), AND FIND $DW^{\#'}(\delta, V_{gtn})$, $R^{\#'}(\delta, V_{gtn})$, $h(\delta, V_{gtn})$, AND $F(\delta, V_{gtn}) = R^{\#'} - h \cdot DW^{\#'}$, WHERE n=1,2,…,20.
ST1.7
CALCULATE STANDARD DEVIATION σ [F(δ)] OF FUNCTION F IN AREA Ω
LET BE $\delta = \delta + Q$, WHERE Q IS 0.01, FOR EXAMPLE
ST1.8
ST1.9
FIND $\delta = \delta_0$ WITH WHICH σ [F(δ)] BE A MINIMUM, AT THIS TIMES, TRUE THRESHOLD VOLTAGE OF NARROW TRANSISTOR IS $V_{thNa} = V_{thWi} + \delta_0$, THRESHOLD VOLTAGE OF WIDE TRANSISTOR IS $V_{thWi} = V_{thWi}$ AS IN ST1.5
MEASURE GATE OVERDRIVE FROM THRESHOLD VOLTAGE IN ST1.9, TO FIND $dW^{**}(V_{gt})$
ST1.10
ST1.11
LET DW OF NARROW TRANSISTOR BE $DW_{Na}(V_{gt}) = dW^{**}(V_{gt})$, AT THIS TIME, EFFECTIVE CHANNEL WIDTH OF W_{Na} OF NARROW TRANSISTOR IS GIVEN BY $W_{effNa}(V_{gt}) = W_{mNa} - DW_{Na}(V_{gt})$

FIG. 21

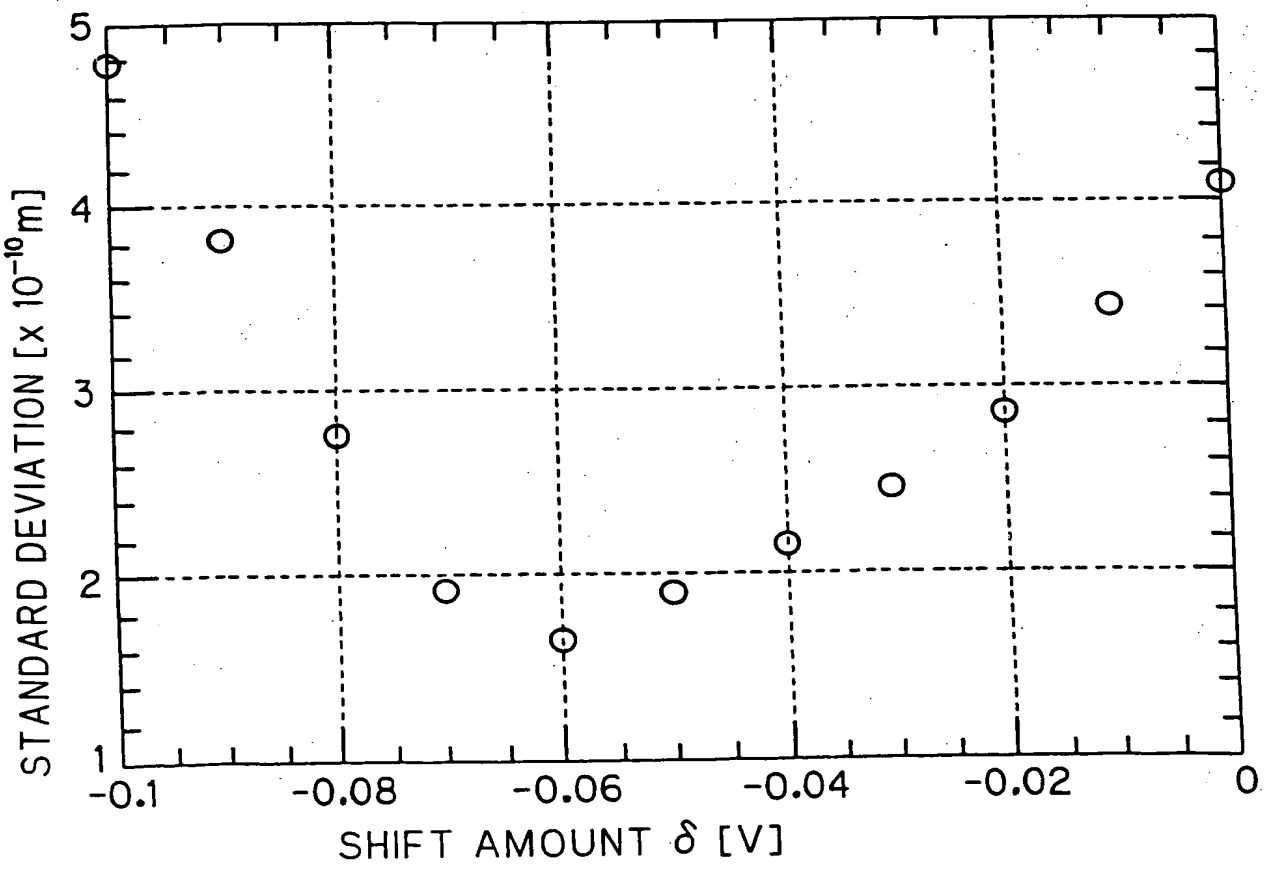

STANDARD DEVIATION [x 10⁻¹⁰m]
5
4
3
2
1
-0.1
-0.08
-0.06
-0.04
-0.02
0
SHIFT AMOUNT δ [V]

FIG. 22

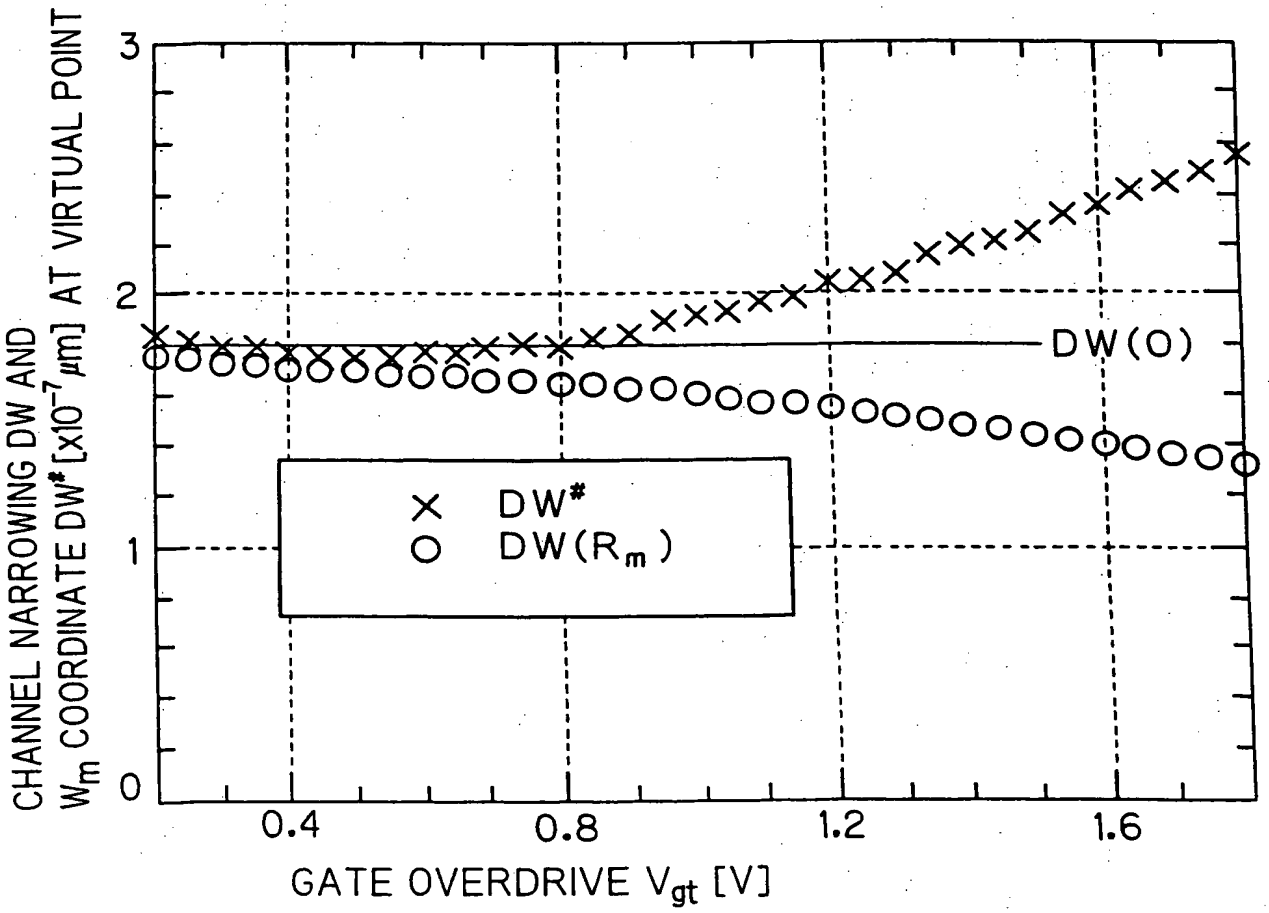

CHANNEL NARROWING DW AND
W_m COORDINATE DW* [$\times 10^{-7}$ μm] AT VIRTUAL POINT
3
2
1
0
0.4
0.8
1.2
1.6
GATE OVERDRIVE V_{gt} [V]
DW(O)
DW*
DW(R_m)

FIG. 23

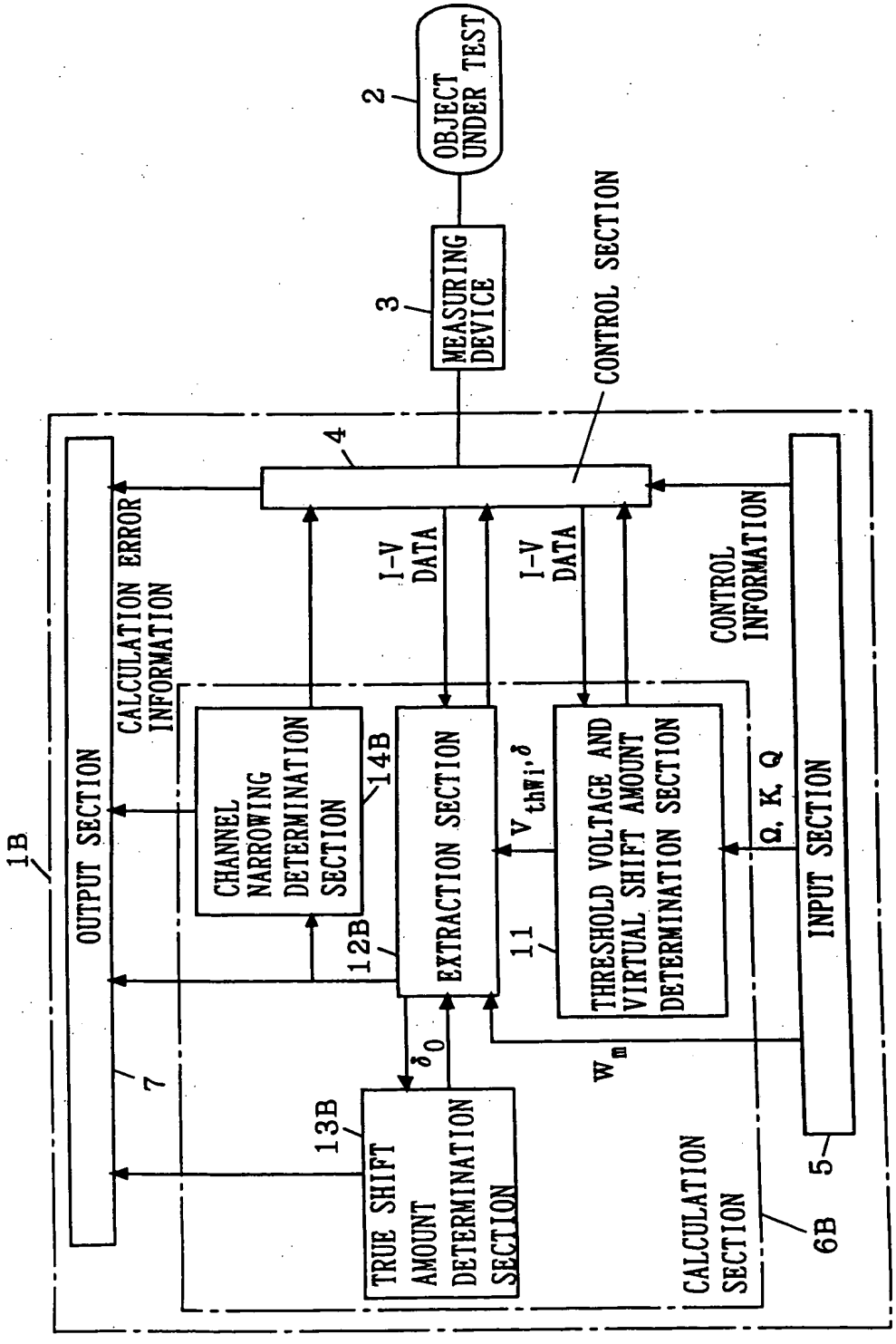

OBJECT UNDER TEST
2
MEASURING DEVICE
3
CONTROL SECTION
4
I-V DATA
I-V DATA
CONTROL INFORMATION
CALCULATION ERROR INFORMATION
OUTPUT SECTION
1B
CHANNEL NARROWING DETERMINATION SECTION
14B
EXTRACTION SECTION
12B
THRESHOLD VOLTAGE AND VIRTUAL SHIFT AMOUNT DETERMINATION SECTION
11
INPUT SECTION
Ω, K, Q
7
TRUE SHIFT AMOUNT DETERMINATION SECTION
13B
CALCULATION SECTION
6B
5

FIG. 24

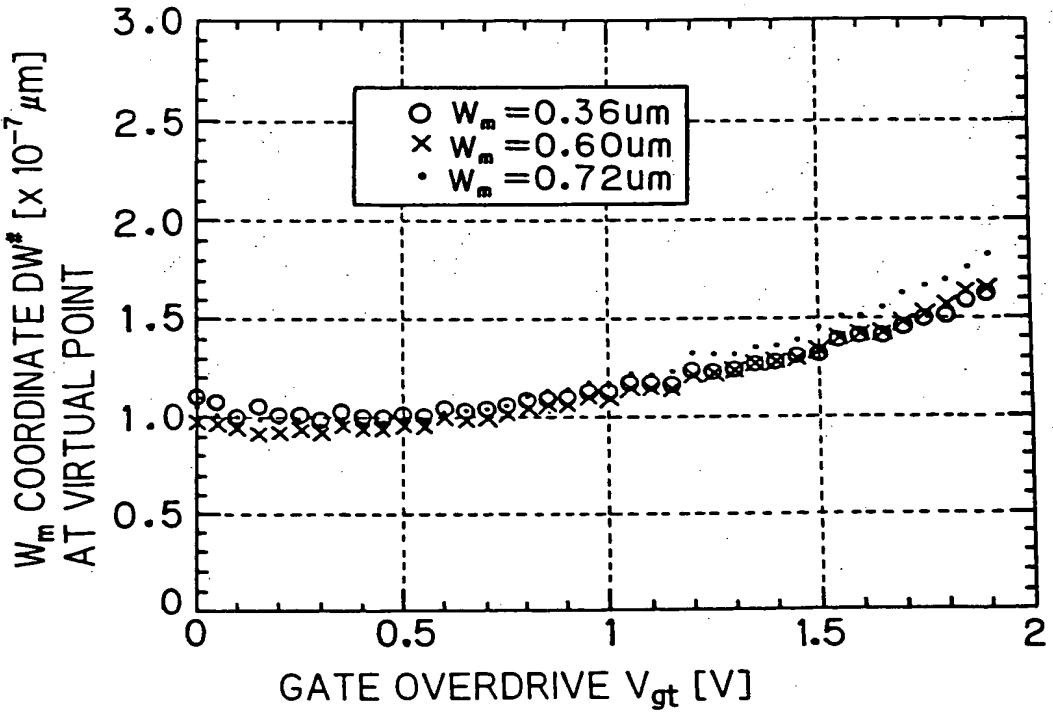

3.0
2.5
2.0
1.5
1.0
0.5
0
0
0.5
1
1.5
2
o W_m=0.36um
× W_m=0.60um
· W_m=0.72um
W_m COORDINATE DW* [x 10^{-7} μm]
AT VIRTUAL POINT
GATE OVERDRIVE V_{gt} [V]

FIG. 25

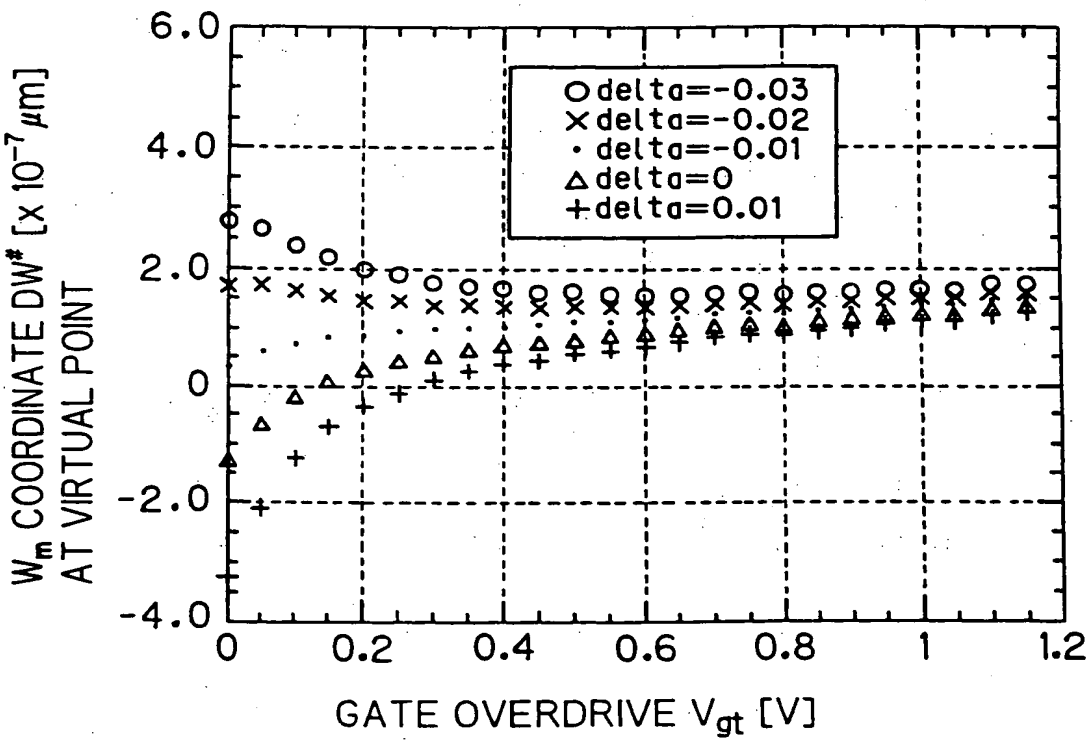

6.0
4.0
2.0
0
-2.0
-4.0
0
0.2
0.4
0.6
0.8
1
1.2
delta=-0.03
delta=-0.02
delta=-0.01
delta=0
delta=0.01
W_m COORDINATE DW* [X 10^{-7} μm]
AT VIRTUAL POINT
GATE OVERDRIVE V_{gt} [V]

FIG. 26

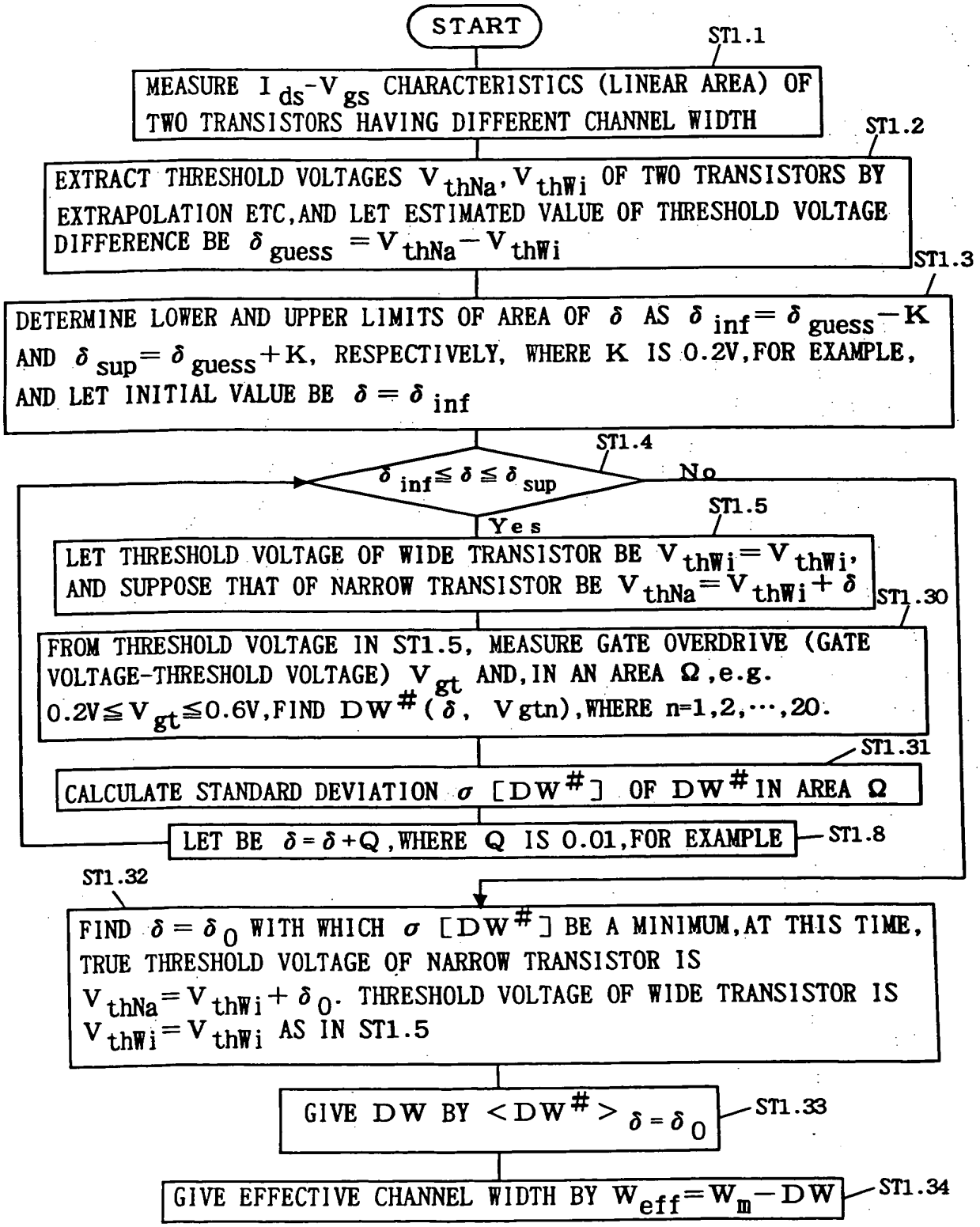

START
ST1.1
MEASURE I_{ds}-V_{gs} CHARACTERISTICS (LINEAR AREA) OF TWO TRANSISTORS HAVING DIFFERENT CHANNEL WIDTH
ST1.2
EXTRACT THRESHOLD VOLTAGES V_{thNa}, V_{thWi} OF TWO TRANSISTORS BY EXTRAPOLATION ETC, AND LET ESTIMATED VALUE OF THRESHOLD VOLTAGE DIFFERENCE BE $\delta_{guess} = V_{thNa} - V_{thWi}$
ST1.3
DETERMINE LOWER AND UPPER LIMITS OF AREA OF δ AS $\delta_{inf} = \delta_{guess} - K$ AND $\delta_{sup} = \delta_{guess} + K$, RESPECTIVELY, WHERE K IS 0.2V, FOR EXAMPLE, AND LET INITIAL VALUE BE $\delta = \delta_{inf}$
ST1.4
$\delta_{inf} \leqq \delta \leqq \delta_{sup}$
No
Yes
ST1.5
LET THRESHOLD VOLTAGE OF WIDE TRANSISTOR BE $V_{thWi} = V_{thWi}$, AND SUPPOSE THAT OF NARROW TRANSISTOR BE $V_{thNa} = V_{thWi} + \delta$
ST1.30
FROM THRESHOLD VOLTAGE IN ST1.5, MEASURE GATE OVERDRIVE (GATE VOLTAGE-THRESHOLD VOLTAGE) V_{gt} AND, IN AN AREA Ω, e.g. $0.2V \leqq V_{gt} \leqq 0.6V$, FIND $DW^{\#}(\delta, Vgtn)$, WHERE n=1,2,…,20.
ST1.31
CALCULATE STANDARD DEVIATION $\sigma[DW^{\#}]$ OF $DW^{\#}$ IN AREA Ω
LET BE $\delta = \delta + Q$, WHERE Q IS 0.01, FOR EXAMPLE
ST1.8
ST1.32
FIND $\delta = \delta_0$ WITH WHICH $\sigma[DW^{\#}]$ BE A MINIMUM, AT THIS TIME, TRUE THRESHOLD VOLTAGE OF NARROW TRANSISTOR IS $V_{thNa} = V_{thWi} + \delta_0$. THRESHOLD VOLTAGE OF WIDE TRANSISTOR IS $V_{thWi} = V_{thWi}$ AS IN ST1.5
GIVE DW BY $<DW^{\#}>_{\delta = \delta_0}$
ST1.33
GIVE EFFECTIVE CHANNEL WIDTH BY $W_{eff} = W_m - DW$
ST1.34

FIG. 27

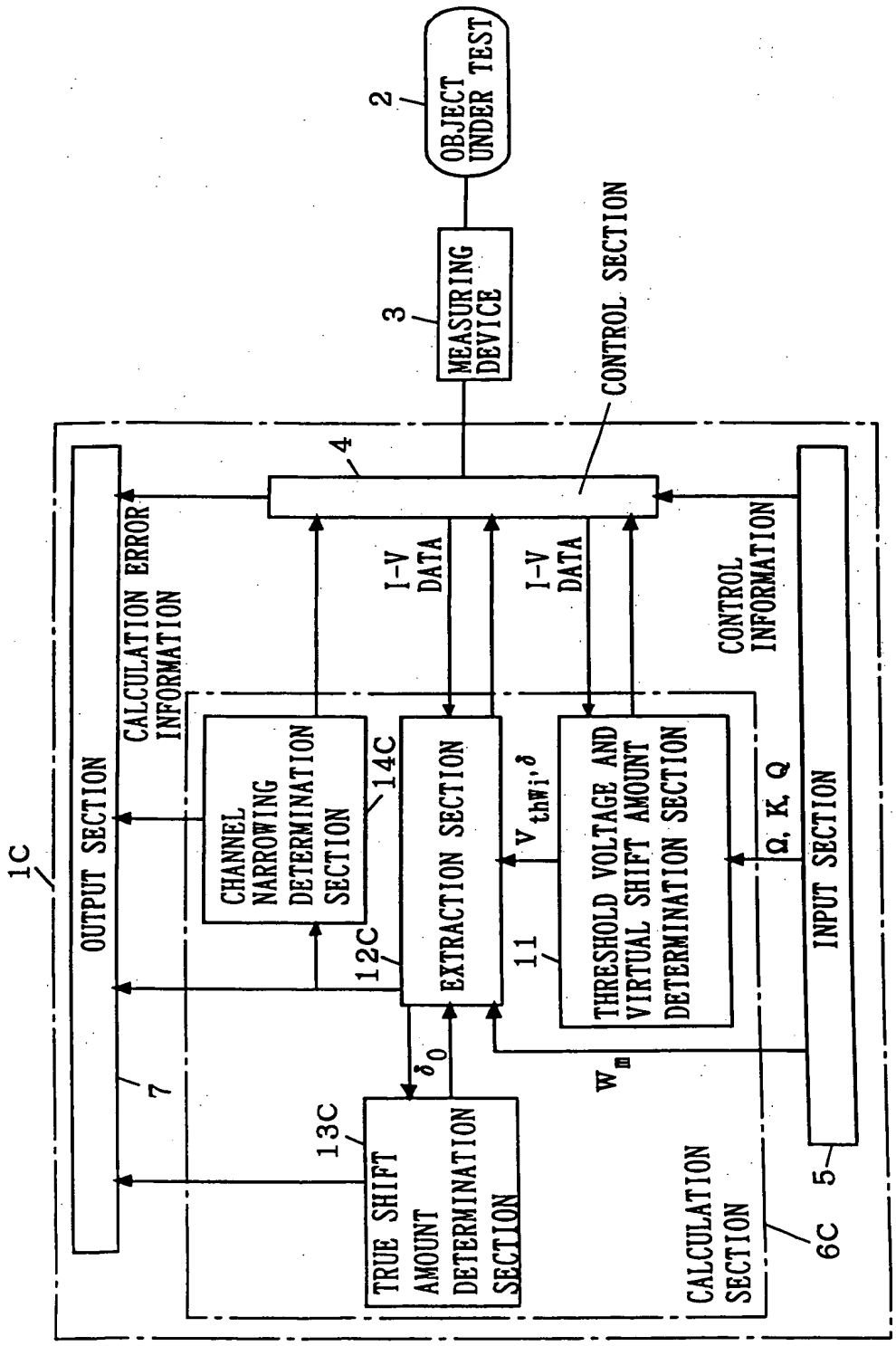

1C
2
OBJECT UNDER TEST
3
MEASURING DEVICE
CONTROL SECTION
4
I-V DATA
I-V DATA
CONTROL INFORMATION
CALCULATION ERROR INFORMATION
OUTPUT SECTION
CHANNEL NARROWING DETERMINATION SECTION
14C
EXTRACTION SECTION
12C
V_{thWi}, δ
THRESHOLD VOLTAGE AND VIRTUAL SHIFT AMOUNT DETERMINATION SECTION
11
Ω, K, Q
INPUT SECTION
7
δ_0
W_m
13C
TRUE SHIFT AMOUNT DETERMINATION SECTION
CALCULATION SECTION
6C
5

FIG. 28

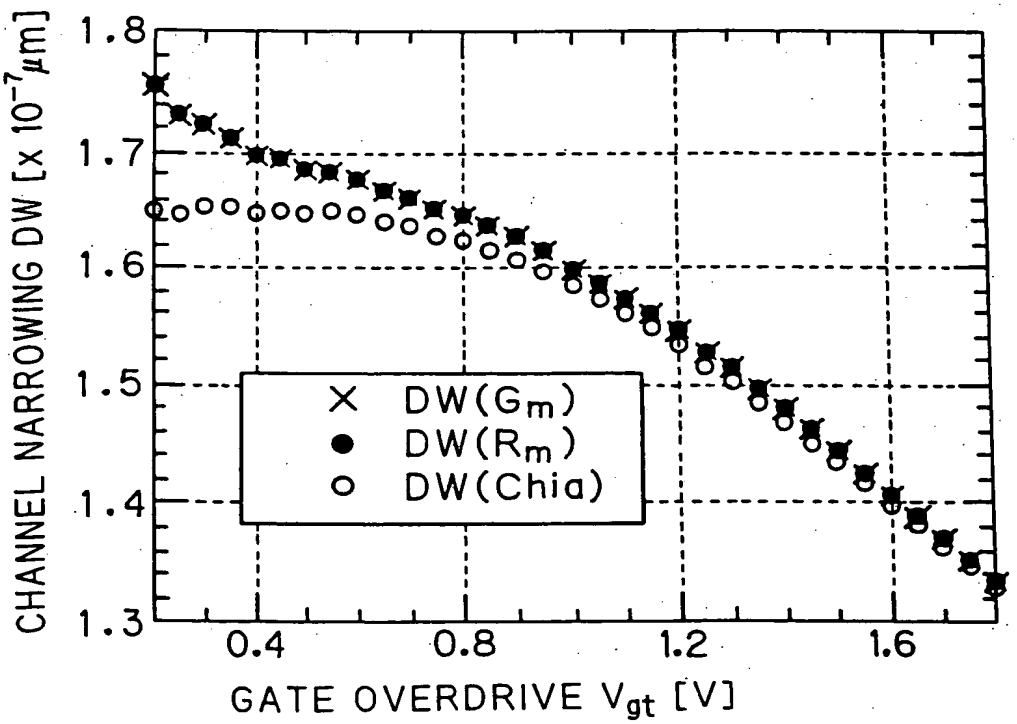
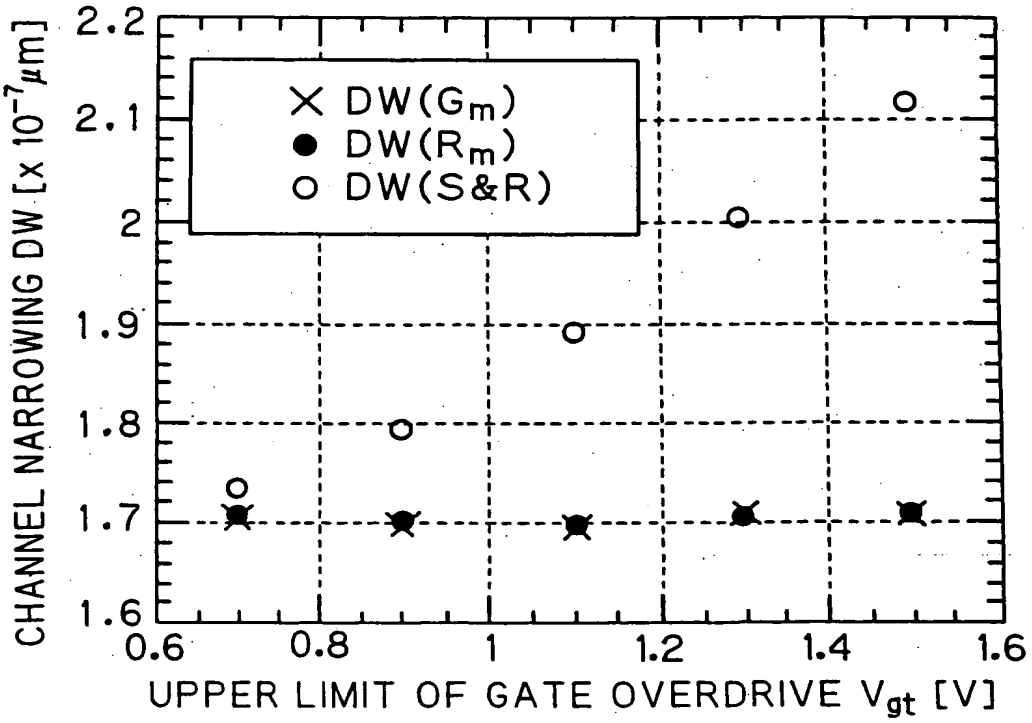

CHANNEL NARROWING DW [x 10⁻⁷μm]
1.8
1.7
1.6
1.5
1.4
1.3
0.4
0.8
1.2
1.6
GATE OVERDRIVE Vgt [V]
DW(Gm)
DW(Rm)
DW(Chia)

FIG. 29


CHANNEL NARROWING DW [x 10⁻⁷μm]
2.2
2.1
2
1.9
1.8
1.7
1.6
DW(Gm)
DW(Rm)
DW(S&R)
0.6
0.8
1
1.2
1.4
1.6
UPPER LIMIT OF GATE OVERDRIVE Vgt [V]